Original Article

MEDICINE PALLIATIVE CARE

DOI: 10.47582/jompac.1626490

J Med Palliat Care. 2025;6(2):78-84

Comparative diagnostic value of novel and traditional anthropometric indices in FibroScan-diagnosed NAFLD among Turkish adults

Murat Keskin[1], Nizameddin Koca[2]

[1]*Department of Gastroenterology, Medicana Bursa Hospital, Bursa, Turkiye*

[2]*Department of Internal Medicine, Bursa Faculty of Medicine, University of Health Sciences, Bursa, Turkiye*

Cite this article as: Keskin M, Koca N. Comparative diagnostic value of novel and traditional anthropometric indices in FibroScan-diagnosed NAFLD among Turkish adults. *J Med Palliat Care*. 2025;6(2):78-84.

Received: 24.01.2025 ◆ **Accepted**: 21.02.2025 ◆ **Published**: 23.03.2025

ABSTRACT

Aims: Nonalcoholic fatty liver disease (NAFLD) is a growing global health concern associated with chronic liver damage and metabolic comorbidities. Traditional anthropometric measures—such as body-mass index (BMI) and waist circumference (WC), have known limitations. This study aimed to compare the diagnostic performance of novel obesity indices, including a body shape index (ABSI) and body roundness index (BRI), with conventional parameters in predicting NAFLD.

Methods: A retrospective study was conducted with 430 Turkish adults (aged 18–74) undergoing FibroScan assessments. Anthropometric data (body weight, height, WC) and controlled attenuation parameter (CAP) values were collected. NAFLD was defined as CAP ≥257 dB/m. Predictive capabilities of BMI, WC, ABSI, BRI, waist-to-height ratio (WHtR), and body weight were compared using receiver operating characteristic (ROC) curve analyses. Pairwise area under-the-curve (AUC) comparisons were performed using the DeLong test, with significance set at $p<0.05$.

Results: Body weight displayed the highest area under the ROC curve (AUC) for NAFLD diagnosis (AUC=0.766; 95% CI: 0.716–0.816). BMI (AUC=0.695; 95% CI: 0.637–0.753) and WC (AUC=0.693; 95% CI: 0.636–0.750) had comparable performance. BRI and WHtR demonstrated lower AUC values (AUC=0.621), while ABSI had insufficient discriminatory ability (AUC=0.485). NAFLD prevalence was significantly higher in males (71% vs. 50%, $p<0.001$), aligning with prior epidemiological reports.

Conclusion: Among Turkish patients diagnosed via FibroScan, body weight emerged as the strongest predictor of NAFLD, with BMI and WC remaining reliable alternatives. Novel indices such as BRI and ABSI showed limited utility for clinical diagnosis. These findings highlight the continued relevance of simple and traditional measurements for identifying NAFLD risk.

Keywords: Nonalcoholic fatty liver disease (NAFLD), anthropometric indices, a body shape index (ABSI), body roundness index (BRI), FibroScan

INTRODUCTION

Nonalcoholic fatty liver disease (NAFLD) is the most common chronic liver disorder worldwide, defined by the accumulation of fat in more than 5% of hepatocytes without secondary causes such as excessive alcohol consumption, viral and autoimmune hepatitis, or congenital liver diseases.[1-3] While most NAFLD patients exhibit isolated hepatic steatosis, a subset may progress to nonalcoholic steatohepatitis (NASH), which can lead to hepatic fibrosis and potentially cirrhosis, hepatocellular carcinoma, and end-stage liver disease.[4,5]

Obesity is a well-established risk factor for NAFLD.[6] Studies show that 50% of individuals with NAFLD and 82% of those with NASH are obese.[7] Given the growing burden of obesity-related diseases, anthropometric measures such as body-mass index (BMI), waist circumference (WC), and waist-to-height ratio (WHtR) have been widely used to assess fatty liver disease severity.[8] BMI and WC are standard indices for evaluating overall and central obesity, known risk factors for NAFLD.[9-11] However, BMI does not differentiate between adipose and lean mass, and WC cannot distinguish visceral from subcutaneous fat distribution.[12-14]

To address these limitations, novel anthropometric indices have been developed, including a body shape index (ABSI) and body roundness index (BRI), which integrate BMI, WC, and height. These indices have been explored for their predictive value in metabolic disorders such as cardiovascular disease, diabetes mellitus, and NAFLD.[15-19]

FibroScan, a widely used noninvasive diagnostic tool, provides reliable quantification of hepatic steatosis and fibrosis using the controlled attenuation parameter (CAP). It offers a better correlation with hepatic fat content compared to conventional ultrasonography.[19-22]

Corresponding Author: Murat Keskin, keskinmd@hotmail.com

This work is licensed under a Creative Commons Attribution 4.0 International License.

This study aims to determine the diagnostic value of traditional anthropometric measurements—BMI, WC, and WHtR—alongside the novel obesity indices ABSI and BRI in identifying NAFLD cases diagnosed via FibroScan. Additionally, we seek to establish which indices are the most robust predictors of NAFLD.

METHODS

Ethics

University of Health Sciences, Bursa Faculty of Medicine, Bursa City Training and Research Hospital Ethics Committee Institutional Review Board (IRB) approved the study protocol (Date: 22.01.2025, Decision No: 2025-2/15). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Study Design and Participants

This retrospective study aimed to compare the predictive power of classic anthropometric measurements—BMI and WC with the novel obesity indices ABSI and BRI for diagnosing NAFLD in adult patients who received a NAFLD diagnosis via FibroScan. Additionally, it sought to determine which index might be more clinically relevant in routine practice.

The study encompassed patients who presented to the gastroenterology outpatient clinic between September 1, 2018, and December 31, 2024, for whom demographic data, anthropometric measurements, and FibroScan-based CAP values were available. In total, 430 patients aged between 18 and 74 years were included.

Inclusion and Exclusion Criteria

Adults aged 18–74 years with recorded height, weight, and WC measurements, as well as adequate and valid CAP data from FibroScan evaluations, were included in the study. Individuals were excluded if they were younger than 18 or older than 74 years; consumed alcohol exceeding 210 g/week (men) or 140 g/week (women); were pregnant; or had a history of hepatitis B, hepatitis C, autoimmune hepatitis, acute hepatitis, primary or secondary cholestatic liver disease, hemochromatosis or other metabolic liver disorders, liver cirrhosis, or malignancy.

Anthropometric and Clinical Measurements

Demographic data (age, sex) and standardized anthropometric measurements (height, weight, WC) were obtained retrospectively from the hospital information system and FibroScan device registry. BMI was calculated by dividing weight in kilograms by the square of height in meters (kg/m^2). WHtR was determined by dividing WC by height in centimeters.

ABSI and BRI were calculated according to the following formulas:

ABSI= WC / (BMI$^{2/3}$ x height$^{1/2}$)

$$BRI = 364.2 - 365.5\sqrt{1 - \left(\frac{\text{waist circumference}}{\pi \times \text{height}}\right)^2}$$

Radiological Assessments

This study retrospectively analyzed patient records from individuals diagnosed with NAFLD via the FibroScan device. Hepatic steatosis was evaluated using a FibroScan 502 Touch model (Echosens, Paris, France) to obtain CAP values. Measurements were performed with either an M or XL probe, and the degree of liver steatosis was recorded in decibels per meter (dB/m). Data from patients with at least 10 valid measurements and a median measurement quality of less than 30% variability were deemed suitable for analysis.

To define hepatic steatosis, a CAP threshold of 257 dB/m or higher, as determined in the biopsy-controlled study by Yılmaz et al.[23], was employed. In that investigation, this cutoff was shown to distinguish marked hepatosteatosis with 89% sensitivity and 83% specificity (AUROC: 0.93).

Statistical Analysis

All statistical procedures were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). The normality of continuous variables was initially assessed via the Kolmogorov-Smirnov test. Variables following a normal distribution were presented as mean±standard deviation and compared using the independent samples t-test. Non-normally distributed data were expressed as median (minimum-maximum) and analyzed using the Mann-Whitney U test. Categorical variables were compared using the Chi-square test, and results were reported as frequencies and percentages.

A receiver operating characteristic (ROC) curve analysis was carried out to determine the diagnostic performance of each anthropometric measure used to detect NAFLD. The area under the ROC curve (AUC) was calculated for body weight, BMI, WC, WHtR, ABSI, and BRI. Higher AUC values indicated greater discriminatory power for diagnosing NAFLD. DeLong's test was used for pairwise comparisons of AUCs. Statistical significance was defined as a two-tailed p-value <0.05.

Based on the findings, the measure with the highest AUC had the strongest predictive capacity, while indices with lower AUC values were considered to have limited clinical utility. Subgroup analyses (e.g., sex differences) were also conducted when applicable.

To determine whether the differences in AUC values among the anthropometric indices were statistically significant, pairwise AUC comparisons were performed using the DeLong test. The DeLong test is a non-parametric method specifically designed to compare correlated ROC curves and provides a p-value indicating whether the difference between two AUC values is statistically significant. The significance level was set at p<0.05.

RESULTS

A total of 430 participants were included in this study, with 334 classified as having fatty liver and 96 as non-fatty liver. The demographic and clinical characteristics of the two groups are presented in **Table 1**.

Table 1. Comparison of demographics between the groups

	Non-fatty liver (n=96)		Fatty liver (n=334)		p
	Mean±SD	Median(min-max)	Mean±SD	Median(min-max)	
Age, years	48.17±13.7	48(20-74)	47.49±11.99	48(18-74)	0.661*
Gender Female, n (%) Male, n (%)		48 (50) 48 (50)		97 (29) 237 (71)	<0.001
Height, cm	167.08±11.39	168(115-189)	172.73±10.11	174(148-196)	<0.001
Weight, kg	77.3±12.02	76.5(50-114)	95.33±51.09	90(56-968)	<0.001
WC, cm	100.54±11.29	103(70-123)	110.03±12.5	108(79-152)	<0.001
ABSI Score	1.1±1.65	1.03(-4.13-9.7)	1.02±1.34	1.02(-6.08-8.04)	0.645
BMI, kg/m²	27.9±5.38	27.49(19.23-65.03)	32.1±20.96	30.47(18.94-402.91)	<0.001
BRI	5.69±2.11	5.3(2.31-16.05)	6.43±1.87	6.04(2.37-14.73)	<0.001
WHtR	0.60±0.08	0.59 (0.44-0.96	0.63±0.07	0.62 (0.44-0.92)	<0.001
CAP, dB/m	223.58±35.63	234(3.4-257)	324.26±34.36	325(258-400)	<0.001
LSM, kPa	8.51±9.2	5.3(2.6-75)	9.31±7.74	6.8(2.4-69.1)	<0.001

SD: Standard deviation, WC: Waist circumference, ABSI: A body shape index, BMI: Body-mass index, BRI: Body roundness index, WHtR: Waist to height ratio, CAP: Controlled attenuated parameter, LSM: Liver stiffness measurement, *: student t-test

Demographic and Anthropometric Comparisons

The mean age of the fatty liver group was 47.49±11.99 years, while the non-fatty liver group had a mean age of 48.17±13.7 years (p=0.661). A significant gender difference was observed between the groups, with a higher proportion of males in the fatty liver group (71%) compared to the non-fatty liver group (50%) (p<0.001).

Key anthropometric variables such as height, weight, WC, BMI, BRI, and WHtR demonstrated significant differences between the groups. The fatty liver group exhibited higher mean WC (110.03±12.5 cm vs. 100.54±11.29 cm, p<0.001), BMI (32.1±20.96 kg/m² vs. 27.9±5.38 kg/m², p<0.001), and WHtR (0.63±0.07 vs. 0.60±0.08, p<0.001). Similarly, weight and BRI were significantly elevated in the fatty liver group.

ROC Curve Analysis

ROC curve analyses were performed to evaluate the predictive power of various anthropometric measures for fatty liver diagnosis (Figure 1). Among the examined indices, body weight demonstrated the highest discriminatory power, with an AUC of 0.766 (95% CI: 0.716–0.816, p<0.001), followed by BMI (AUC=0.695, 95% CI: 0.637–0.753, p<0.001) and WC (AUC=0.693, 95% CI: 0.636–0.750, p<0.001), both of which showed moderate predictive accuracy. Conversely, WHtR and BRI exhibited lower discriminative ability with identical AUC values of 0.621 (95% CI: 0.554–0.688, p<0.001). The ABSI had the weakest predictive performance (AUC=0.485, 95% CI: 0.414–0.555, p=0.668), indicating that it was not useful for distinguishing NAFLD cases from controls.

The DeLong test was performed to compare the AUC values (Table 2) statistically. The results showed that body weight significantly outperformed all other indices (p<0.05 in all comparisons), confirming its superior predictive ability. BMI and WC performed similarly, as their AUC values were not significantly different (p=0.841). WHtR and BRI performed similarly (p=0.912), indicating neither provided superior discriminatory power. In contrast, ABSI was significantly inferior to all other indices (p<0.001 in all cases except

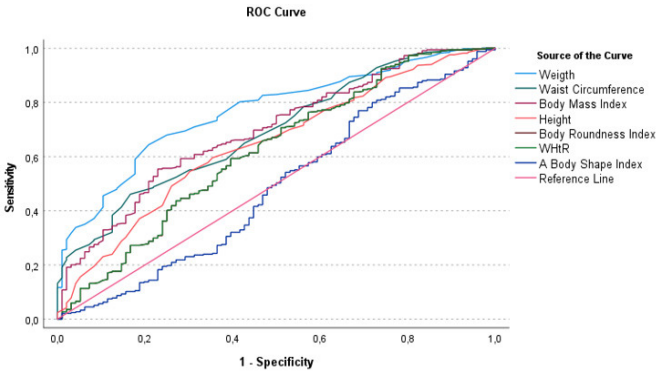

Figure 1. ROC curve analysis
ROC: Receiver operating characteristic

height), reinforcing its limited clinical utility. These findings suggest that body weight, BMI, and WC are the most effective anthropometric measures for NAFLD risk assessment, whereas ABSI lacks predictive value in this cohort.

Model Quality and Discriminative Metrics

The model quality scores, and classifier evaluation metrics are summarized in Table 3 and Table 4. Weight demonstrated the highest model quality (Gini index=0.532; Max K-S=0.435). WC (Gini index=0.387; Max K-S=0.294) and BMI (Gini index=0.390; Max K-S=0.325) also showed strong discriminative performance. WHtR had a moderate Gini index of 0.242 and a Max K-S value of 0.197.

Overall Model Quality

The overall model quality, shown in Figure 2, reaffirmed weight as the strongest predictor, with a quality score of 0.72. BMI and WC shared a quality score of 0.64, while WHtR and BRI had equally a lower model quality score of 0.55. ABSI had the lowest quality score (0.41), making it the least effective predictor among the variables analyzed.

DISCUSSION

Early and accurate detection of NAFLD is crucial for preventing the progression of chronic liver disease and related comorbid conditions. Hence, there is a pressing need

Table 2. Pairwise DeLong test p-values for AUC comparisons

Variable	Height	Weight	WC	BMI	BRI	WHtR	ABSI
Height	—	0.002*	0.051	0.038*	0.017*	0.019*	0.256
Weight	0.002*	—	0.006*	0.004*	0.002*	0.002*	<0.001*
WC	0.051	0.006*	—	0.841	0.093	0.042*	<0.001*
BMI	0.038*	0.004*	0.841	—	0.049*	0.018*	<0.001*
BRI	0.017*	0.002*	0.093	0.049*	—	0.912	<0.001*
WHtR	0.019*	0.002*	0.042*	0.018*	0.912	—	<0.001*
ABSI	0.256	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	—

AUC: Area under-the-curve, WC: Waist circumference, ABSI: A body shape index, BMI: Body-mass index, BRI: Body roundness index, WHtR: Waist to height ratio,*: Indicate statistically significant differences

Table 3. Area under the ROC curve

	Area	Std. error[a]	Asymptotic sig.[b]	Asymptotic 95% confidence interval	
				Lower bound	Upper bound
Height, cm	0.644	0.032	0.000	0.582	0.706
Weight, kg	0.766	0.025	0.000	0.716	0.816
Waist circumference, cm	0.693	0.029	0.000	0.636	0.750
A body shape index	0.485	0.036	0.668	0.414	0.555
Body-mass index, kg/m^2	0.695	0.030	0.000	0.637	0.753
Body roundness index	0.621	0.034	0.000	0.554	0.688
Waist-to-height ratio	0.621	0.034	0.000	0.554	0.688

ROC: Receiver operating characteristic, a. Under the nonparametric assumption, b. Null hypothesis: true area=0.5

Table 4. Classifier evaluation metrics

	Gini index	K-S statistics	
		Max K-S[a]	Cutoff[b]
Height, cm	0.288	0.243	172.50
Weight, kg	0.532	0.435	85.500
Waist circumference, cm	0.387	0.294	109.500
A body shape index	-0.031	0.082	0.2931200000
Body-mass index, kg/m^2	0.390	0.325	29.7164
Body roundness index	0.242	0.197	5.5859
Waist-to-height ratio	0.242	0.197	0.6069

a. The maximum Kolmogorov-Smirnov (K-S) metric, b. In case of multiple cutoff values associated with max K-S, the largest one is reported

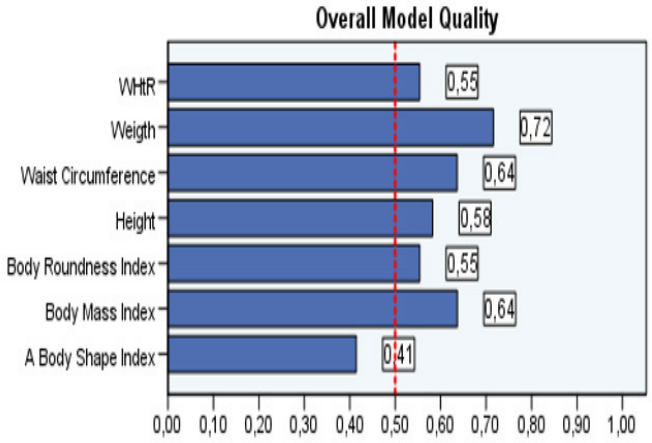

Figure 2. Overall model quality

for effective predictive indicators in clinical practice. In this study, we compared the predictive value of newly developed anthropometric indices with those of more traditional measures for NAFLD diagnosis. Earlier investigations suggested that age and sex might significantly influence NAFLD prevalence.[23,24] However, our findings showed no significant age difference between patients with and without fatty liver disease, indicating that age may not be a predictive factor in our cohort. Consistent with previous research showing that NAFLD predominantly affects males,[25] we also observed a higher prevalence among men in our study.

The observed gender disparity in NAFLD prevalence, with a higher occurrence in men (71% vs. 50%, p<0.001), aligns with current epidemiological findings and is influenced by hormonal, genetic, and metabolic factors. Several studies confirm that NAFLD is more prevalent in men than in premenopausal women due to the protective effects of estrogen, which helps regulate lipid metabolism and reduce hepatic fat accumulation. However, this protection diminishes after menopause, leading to an increased NAFLD risk in postmenopausal women.[26] A recent study analyzing transcriptomic differences suggests that immune responsiveness differs between men and women, with men showing an impaired liver regenerative response and increased inflammation.[27] Additionally, a meta-analysis revealed that while men are more likely to develop NAFLD, women—especially postmenopausal—experience more severe complications, including cardiovascular events.[28] These findings suggest that sex-specific screening and management strategies are essential for improving NAFLD outcomes in both men and women.

Numerous reports have highlighted a strong association between obesity and NAFLD, noting that this relationship persists in both early and advanced disease stages.[3,29,30] Common anthropometric indices, such as BMI and WC, have certain limitations, particularly in differentiating lean muscle mass from adipose tissue, thereby limiting their accuracy in predicting total body fat percentage.[31] Furthermore, visceral adiposity has been identified as the principal fat depot responsible for NAFLD, demonstrating a dose-dependent relationship with the disease.[32] Although robust correlations between conventional anthropometric measurements and NAFLD have been consistently reported, recent research has begun exploring new indices to evaluate their potential for distinguishing between patients with and without fatty liver disease.[33,34]

Thomas et al.[21] employed the BRI to estimate total and visceral adiposity. Previous studies likewise found that BRI holds promise as a clinical predictor for metabolic syndrome and is strongly correlated with NAFLD.[35,36] In another study by Tian et al.[37], transient elastography was used to determine CAP values, and BRI demonstrated superior diagnostic capability compared to BMI. Supporting these results, additional research has revealed that BRI and WHtR can exhibit high AUC values for diagnosing NAFLD.[36] However, our findings diverged from these reports by showing that BRI had a lower diagnostic value than body weight and BMI in identifying fatty liver.

Among the novel anthropometric indices, ABSI has been proposed as a potential predictor for conditions such as diabetes mellitus, cardiovascular disease, and hyperuricemia.[19-21] Nonetheless, a study investigating the relationship between ABSI and NAFLD reported insufficient predictive power for ABSI in diagnosing NAFLD.[37] Similarly, in a comparative analysis by Xie et al.[38] examining obesity-related indices for NAFLD detection, BMI emerged as the measure with the highest AUC. In contrast, ABSI, with an AUC of 0.578, failed to achieve adequate sensitivity and specificity. Another study also reported higher AUC values for BMI compared to ABSI and BRI.[39]

In our current study, measuring body weight yielded the most substantial predictive value for diagnosing NAFLD, followed closely by BMI and WC with similar predictive strengths. Meanwhile, BRI and WHtR possessed only modest predictive utility, and ABSI offered insufficient predictive accuracy for clinical use. Our findings align with other work suggesting that BRI and ABSI may lack adequate discriminatory power in differentiating fatty from non-fatty liver.[34]

Strengths and Limitations of the Study

Few studies have investigated the predictive utility of these newer anthropometric measures for diagnosing NAFLD in Turkish patients. Thus, our findings offer preliminary insights into whether these indices are suitable for this population. A notable strength is the relatively large sample size compared to prior reports. Additionally, NAFLD diagnosis was established using FibroScan-based CAP measurements, which are superior to conventional abdominal ultrasound.

Several limitations should also be acknowledged. First, this was a retrospective study. Second, comorbidities such as diabetes mellitus, hyperlipidemia, and hyperuricemias, as well as demographic factors like smoking history and physical activity—were not included in the analysis. Finally, although CAP measurements provide high sensitivity and specificity, the gold standard for NAFLD diagnosis remains liver biopsy, which was unavailable for our patient cohort; consequently, no histopathological comparison could be performed.

Limitations

One of the primary limitations of this study is the absence of data on comorbid conditions, particularly diabetes mellitus, which is a well-established risk factor for NAFLD. Diabetes is strongly associated with hepatic steatosis, insulin resistance, and disease progression, and its exclusion from the analysis may have influenced the predictive accuracy of anthropometric indices in diagnosing NAFLD. The interplay between metabolic disorders and NAFLD suggests that patients with diabetes might exhibit different anthropometric profiles, potentially altering the diagnostic performance of the indices evaluated. Future studies should incorporate detailed metabolic and comorbidity data to provide a more comprehensive understanding of their impact on NAFLD prevalence and severity.

CONCLUSION

In this cohort of Turkish patients diagnosed with NAFLD via Fibroscan, body weight emerged as the strongest predictor for detecting NAFLD, followed closely by BMI and WC, which showed similar predictive performance. By contrast, BRI and WHtR demonstrated limited utility, whereas ABSI appeared unsuitable for clinical implementation. Furthermore, these findings corroborate previous studies indicating a higher prevalence of NAFLD among male patients.

ETHICAL DECLARATIONS

Ethics Committee Approval

University of Health Sciences, Bursa Faculty of Medicine, Bursa City Training and Research Hospital Ethics Committee Institutional Review Board (IRB) approved the study protocol (Date: 22.01.2025, Decision No: 2025-2/15).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

REFERENCES

1. Sanyal AJ, Brunt EM, Kleiner DE, et al. Endpoints and clinical trial design for nonalcoholic steatohepatitis. *Hepatology*. 2011;54(1):344-353. doi:10.1002/hep.24376
2. Chalasani N, Younossi Z, Lavine JE, et al. The diagnosis and management of nonalcoholic fatty liver disease: practice guidance from the American association for the study of liver diseases. *Hepatology*. 2018;67(1):328-357. doi:10.1002/hep.29367
3. European association for the study of the liver (EASL); European association for the study of diabetes (EASD); European association for the study of obesity (EASO). EASL-EASD-EASO Clinical Practice Guidelines on the management of metabolic dysfunction-associated steatotic liver disease (MASLD). *J Hepatol*. 2024;81(3):492-542. doi:10.1016/j.jhep.2024.04.031
4. Calzadilla Bertot L, Adams LA. The natural course of non-alcoholic fatty liver disease. *Int J Mol Sci*. 2016;17(5):774. doi:10.3390/ijms17050774
5. Ekstedt M, Nasr P, Kechagias S. Natural history of NAFLD/NASH. *Curr Hepatol Rep*. 2017;16(4):391-397. doi:10.1007/s11901-017-0378-2
6. GBD 2019 diseases and injuries collaborators. Global burden of 369 diseases and injuries in 204 countries and territories, 1990-2019: a systematic analysis for the global burden of disease study 2019. *Lancet*. 2020;396(10258):1204-1222. doi:10.1016/S0140-6736(20)30925-9
7. Younossi ZM, Koenig AB, Abdelatif D, Fazel Y, Henry L, Wymer M. Global epidemiology of nonalcoholic fatty liver disease-meta-analytic assessment of prevalence, incidence, and outcomes. *Hepatology*. 2016;64(1):73-84. doi:10.1002/hep.28431
8. Farrell GC, Wong VW, Chitturi S. NAFLD in Asia--as common and important as in the West. *Nat Rev Gastroenterol Hepatol*. 2013;10(5):307-318. doi:10.1038/nrgastro.2013.34
9. Polyzos SA, Kountouras J, Mantzoros CS. Obesity and nonalcoholic fatty liver disease: from pathophysiology to therapeutics. *Metabolism*. 2019;92:82-97. doi:10.1016/j.metabol.2018.11.014
10. VanWagner LB, Khan SS, Ning H, et al. Body-mass index trajectories in young adulthood predict non-alcoholic fatty liver disease in middle age: the CARDIA cohort study. *Liver Int*. 2018;38(4):706-714. doi:10.1111/liv.13603
11. Pang Q, Zhang JY, Song SD, et al. Central obesity and nonalcoholic fatty liver disease risk after adjusting for body-mass index. *World J Gastroenterol*. 2015;21(5):1650-1662. doi:10.3748/wjg.v21.i5.1650
12. Xing J, Guan X, Zhang Q, Chen S, Wu S, Sun X. Triglycerides mediate body-mass index and nonalcoholic fatty liver disease: a population-based study. *Obes Facts*. 2021;14(2):190-196. doi:10.1159/000514848
13. Church TS, Kuk JL, Ross R, Priest EL, Biltoft E, Blair SN. Association of cardiorespiratory fitness, body mass index, and waist circumference to nonalcoholic fatty liver disease. *Gastroenterology*. 2006;130(7):2023-2030. doi:10.1053/j.gastro.2006.03.019
14. Kim D, Chung GE, Kwak MS, et al. Body fat distribution and risk of incident and regressed nonalcoholic fatty liver disease. *Clin Gastroenterol Hepatol*. 2016;14(1):132-8.e4. doi:10.1016/j.cgh.2015.07.024
15. Moore JB. Non-alcoholic fatty liver disease: the hepatic consequence of obesity and the metabolic syndrome. *Proc Nutr Soc*. 2010;69(2):211-220. doi:10.1017/S0029665110000030
16. Blundell JE, Dulloo AG, Salvador J, Frühbeck G; EASO SAB Working Group on BMI. Beyond BMI--phenotyping the obesities. *Obes Facts*. 2014;7(5):322-328. doi:10.1159/000368783
17. Michels KB, Greenland S, Rosner BA. Does body-mass index adequately capture the relation of body composition and body size to health outcomes? *Am J Epidemiol*. 1998;147(2):167-172. doi:10.1093/oxfordjournals.aje.a009430
18. Fang H, Berg E, Cheng X, Shen W. How to best assess abdominal obesity. *Curr Opin Clin Nutr Metab Care*. 2018;21(5):360-365. doi:10.1097/MCO.0000000000000485
19. Chang Y, Guo X, Li T, Li S, Guo J, Sun Y. A body shape index and body roundness index: two new body indices to identify left ventricular hypertrophy among rural populations in Northeast China. *Heart Lung Circ*. 2016;25(4):358-364. doi:10.1016/j.hlc.2015.08.009
20. Maessen MF, Eijsvogels TM, Verheggen RJ, Hopman MT, Verbeek AL, de Vegt F. Entering a new era of body indices: the feasibility of a body shape index and body roundness index to identify cardiovascular health status. *PLoS One*. 2014;9(9):e107212. doi:10.1371/journal.pone.0107212
21. Thomas DM, Bredlau C, Bosy-Westphal A, et al. Relationships between body roundness with body fat and visceral adipose tissue emerging from a new geometrical model. *Obesity (Silver Spring)*. 2013;21(11):2264-2271. doi:10.1002/oby.20408
22. Zhang N, Chang Y, Guo X, Chen Y, Ye N, Sun Y. A body shape index and body roundness index: two new body indices for detecting association between obesity and hyperuricemia in rural area of China. *Eur J Intern Med*. 2016;29:32-36. doi:10.1016/j.ejim.2016.01.019
23. Yilmaz Y, Yesil A, Gerin F, et al. Detection of hepatic steatosis using the controlled attenuation parameter: a comparative study with liver biopsy. *Scand J Gastroenterol*. 2014;49(5):611-616. doi:10.3109/00365521.2014.881548
24. Andronescu CI, Purcarea MR, Babes PA. Nonalcoholic fatty liver disease: epidemiology, pathogenesis and therapeutic implications. *J Med Life*. 2018;11(1):20-23.
25. Wijarnpreecha K, Panjawatanan P, Aby E, Ahmed A, Kim D. Nonalcoholic fatty liver disease in the over-60s: Impact of sarcopenia and obesity. *Maturitas*. 2019;124:48-54. doi:10.1016/j.maturitas.2019.03.016
26. Nagral A, Bangar M, Menezes S, et al. Gender differences in nonalcoholic fatty liver disease. *Euroasian J Hepatogastroenterol*. 2022;12(Suppl 1):S19-S25. doi:10.5005/jp-journals-10018-1370
27. Català-Senent JF, Hidalgo MR, Berenguer M, et al. Sex differences in the progression from NAFL to NASH: a functional meta-analysis of transcriptomic studies medRxiv preprint. *medRxiv*. 2020.06.03.20118570; doi:10.1101/2020.06.03.20118570
28. Khalid Y, Dasu N, Suga H, et al. Increased incidence and prevalence of cardiovascular events and mortality in female patients with NAFLD: a meta-analysis and meta-regression. *Int J Clin Cardiol*. 2020;7(4):1-13. doi:10.23937/2378-2951/1410187
29. Cai MJ, Kong XN, Zhao XY. Influences of gender and age on the prevalence and complications of nonalcoholic fatty liver disease. *Zhongguo Yi Xue Ke Xue Yuan Xue Bao*. 2017;39(4):499-505. doi:10.3881/j.issn.1000-503X.2017.04.007
30. Mahli A, Hellerbrand C. *Alcohol and obesity: a dangerous association for fatty liver disease. Dig Dis*. 2016;34(Suppl 1):p.32-39. doi:10.1159/000447279
31. Li L, Liu DW, Yan HY, Wang ZY, Zhao SH, Wang B. Obesity is an independent risk factor for non-alcoholic fatty liver disease: evidence from a meta-analysis of 21 cohort studies. *Obes Rev*. 2016;17(6):510-519. doi:10.1111/obr.12407
32. Frankenfield DC, Rowe WA, Cooney RN, Smith JS, Becker D. Limits of body mass index to detect obesity and predict body composition. *Nutrition*. 2001;17(1):26-30. doi:10.1016/s0899-9007(00)00471-8
33. Tian T, Zhang J, Zhu Q, Xie W, Wang Y, Dai Y. Predicting value of five anthropometric measures in metabolic syndrome among Jiangsu Province, China. *BMC Public Health*. 2020;20(1):1317. doi:10.1186/s12889-020-09423-9
34. Khan SH, Hafeez A, Khan Y, Chaudhry N, Khalid UB, Shah S. Differences between conventional and newer anthropometric measures among individuals with and without fatty liver disease. *J Coll Physicians Surg Pak*. 2023;33(11):1327-1329. doi:10.29271/jcpsp.2023.11.1327
35. Stefanescu A, Revilla L, Lopez T, Sanchez SE, Williams MA, Gelaye B. Using a body shape index (ABSI) and body roundness index (BRI) to predict risk of metabolic syndrome in Peruvian adults. *J Int Med Res*. 2020;48(1):300060519848854. doi:10.1177/0300060519848854
36. Motamed N, Rabiee B, Hemasi GR, et al. Body roundness index and waist-to-height ratio are strongly associated with non-alcoholic fatty liver disease: a population-based study. *Hepat Mon*. 2016;16(9):e39575. doi:10.5812/hepatmon.39575

37. Tian X, Ding N, Su Y, Qin J. Comparison of obesity-related indicators for nonalcoholic fatty liver disease diagnosed by transient elastography. *Turk J Gastroenterol*. 2023;34(10):1078-1087. doi:10.5152/tjg.2023.23101
38. Xie F, Pei Y, Zhou Q, Cao D, Wang Y. Comparison of obesity-related indices for identifying nonalcoholic fatty liver disease: a population-based cross-sectional study in China. *Lipids Health Dis*. 2021;20(1):132. doi:10.1186/s12944-021-01560-3
39. Wang H, Zhang Y, Liu Y, et al. Comparison between traditional and new obesity measurement index for screening metabolic associated fatty liver disease. *Front Endocrinol (Lausanne)*. 2023;14:1163682. doi:10.3389/fendo.2023.1163682